SUNROM TECHNOLOGIES
Your Source for Embedded Systems

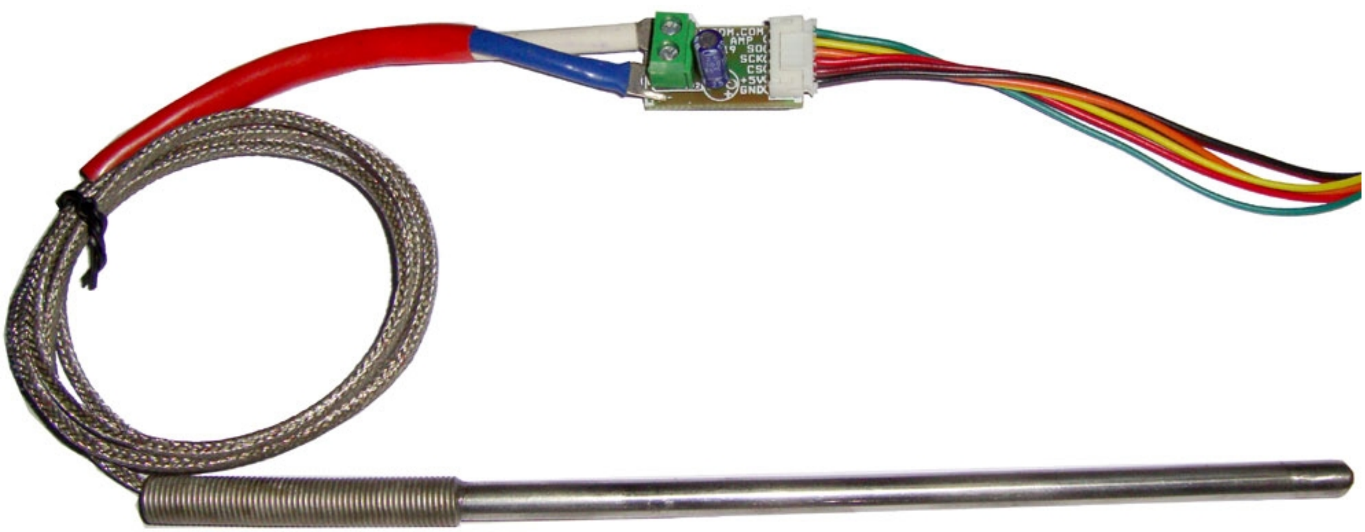
Email: info@sunrom.com

Visit us at http://www.sunrom.com

Document: Datasheet | Date: 5-Jun-10 | Model #: 1219 | Product's Page: www.sunrom.com/p-902.html

Temperature Probe using 'K'-Thermocouple – Digital Interface

This board include a 'K' type thermocouple probe with digital interface. Measures temperature from 0 to +1024 deg Celcus with 0.25 deg C resolution. Output is simple serial SPI interface to be used with any microcontroller. The board performs cold-junction compensation and digitizes the signal from a type-K thermocouple. The data is output in a 12-bit resolution, SPI™-compatible, read-only format. This converter resolves temperatures to 0.25°C, allows readings as high as +1024°C.



Features

- Covers almost entire range from 0 to +1024 deg C in resolution of 0.25 deg C
- Highly accurate 12-Bit results having 0.25°C Resolution
- Direct Digital Conversion of Type –K Thermocouple Output
- Cold-Junction Compensation
- Simple SPI-Compatible Serial Interface
- Open Thermocouple Detection

Applications

- Heat Exchanges & Furnaces
- Industrial Monitoring and Control
- Appliances Control
- HVAC Environment Monitoring
- Automotive Applications like ECU, Exhaust Gas temperature measurement

Specification

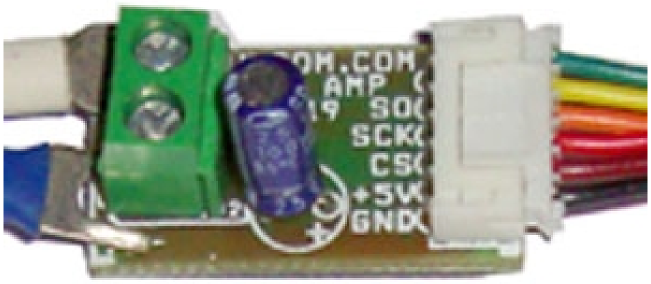
Parameter	Min	Typical	Max	Unit
Operating Voltage	3	5	5.5	V
Current Consumption	0.7		10	mA
Conversion Time		0.17	0.22	Seconds
Resolution		0.25		Deg C
Serial Clock Frequency			4.3	Mhz

Pin Details

These pins are marked on PCB as follows

#	Symbol	Name	Details
1	GND	Ground	Power Supply Ground
2	+5V	Positive	Power Supply +5V DC regulated
3	CS	Chip Select	Active low Chip Select Input, Set CS low to enable serial interface
4	SCK	Serial Clock	Serial Clock Input
5	SO	Serial Out	Serial Data Out
6	N.C.	No connect	Not used

Thermocouple Probe pins



Green connector is screw terminal for connection of thermocouple

Pin	Details
TC-	Alumel Lead of Type-K Thermocouple.
TC+	Chromel Lead of Type- K Thermocouple

Information

The board is a sophisticated thermocouple-to-digital converter with a built-in 12-bit analog-to-digital converter (ADC). The board also contains cold-junction compensation sensing and correction, a digital controller, an SPI-compatible interface, and associated control logic. The board is designed to work in conjunction with an external microcontroller (µC) or other intelligence in thermostatic, process-control, or monitoring applications.

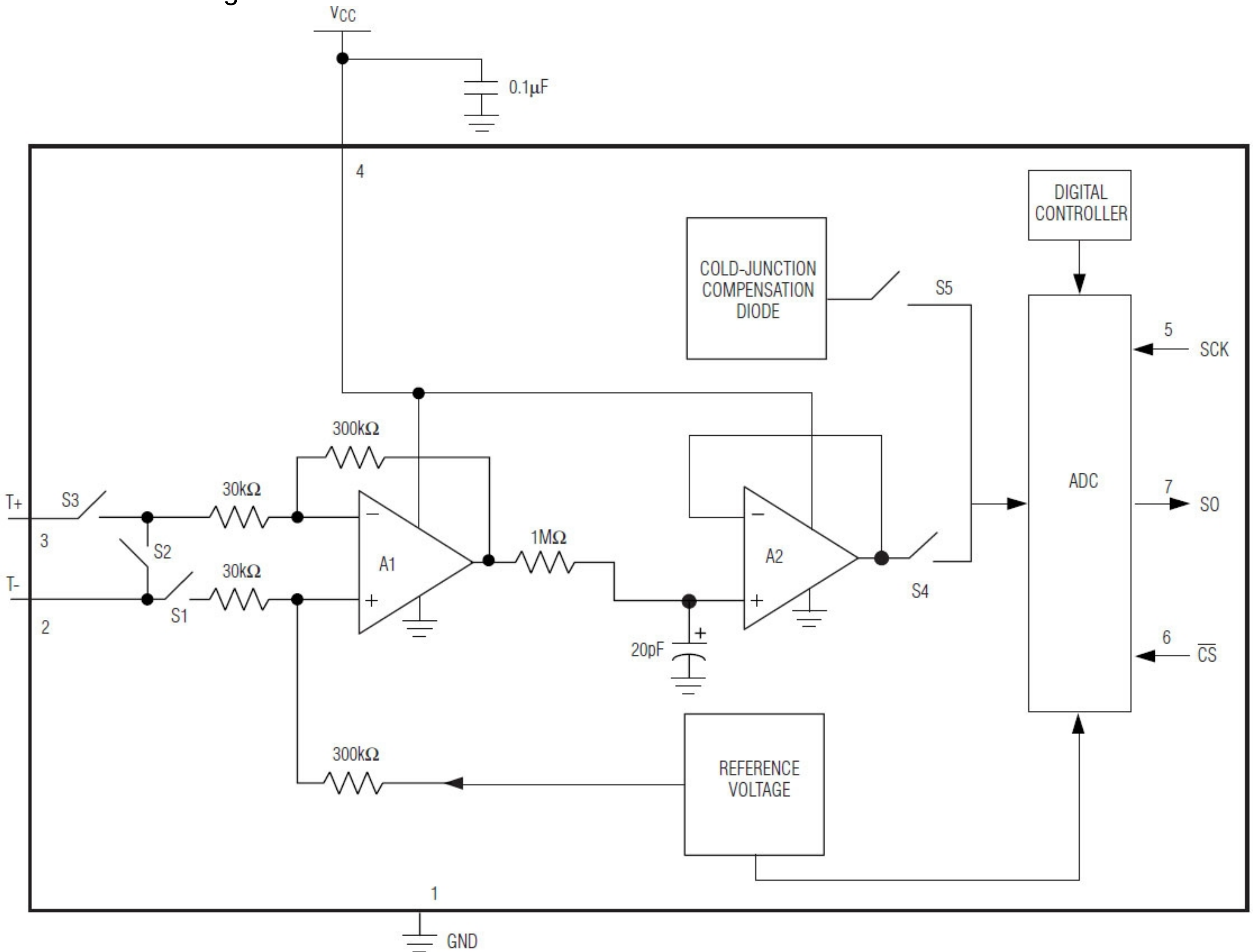
Temperature Conversion

The board includes signal-conditioning hardware to convert the thermocouple's signal into a voltage compatible with the input channels of the ADC. The thermocouple probe leads connect to internal circuitry that reduces the introduction of noise errors from the thermocouple wires. Before converting the thermoelectric voltages into equivalent temperature values, it is necessary to compensate for the difference between the thermocouple cold-junction side (ambient temperature) and a 0°C virtual reference. For a type-K thermocouple, the voltage changes by 41µV/°C, which approximates the thermocouple characteristic with the following linear equation:

$$VOUT = (41\mu V / °C) \times (TR - TAMB)$$

Where:
VOUT is the thermocouple output voltage (µV).
TR is the temperature of the remote thermocouple junction (°C).
TAMB is the ambient temperature (°C).

Internal Block Diagram



Cold Junction Compensation

The function of the thermocouple is to sense a difference in temperature between two ends of the thermocouple wires. The thermocouple‘s hot junction can be read from 0°C to +1023.75°C. The cold end (ambient temperature of the board on which the board is mounted) can only range from -20°C to +85°C. While the temperature at the cold end fluctuates, the board continues to accurately sense the temperature difference at the opposite end.

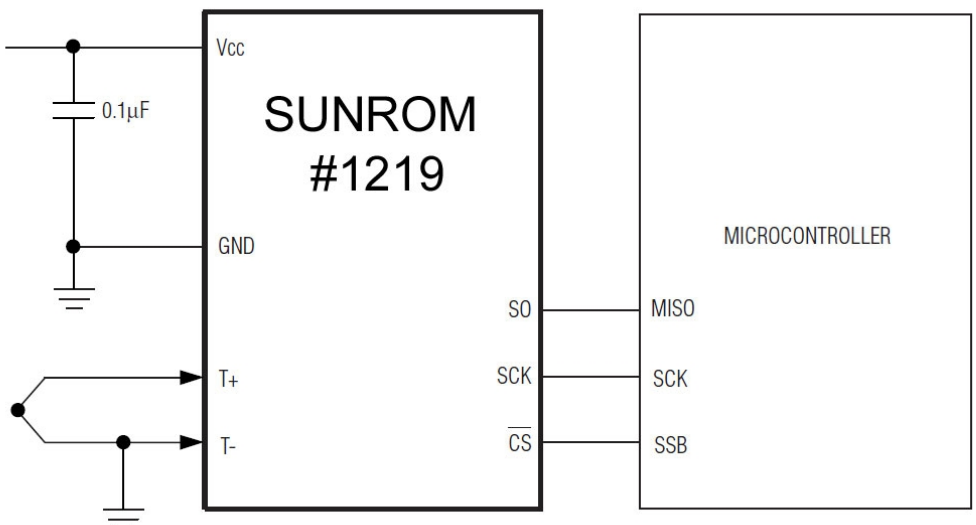
The board senses and corrects for the changes in the ambient temperature with cold-junction compensation. The device converts the ambient temperature reading into a voltage using a temperature-sensing diode. To make the actual thermocouple temperature measurement, the board measures the voltage from the thermocouple's output and from the sensing diode. The device's internal circuitry passes the diode's voltage (sensing ambient temperature) and thermocouple voltage (sensing remote temperature minus ambient temperature) to the conversion function stored in the ADC to calculate the thermocouple's hot-junction temperature.
Optimal performance from the board is achieved when the thermocouple cold junction and the board are at the same temperature. Avoid placing heat-generating devices or components near the board because this may produce cold-junction-related errors.

Digitization

The ADC adds the cold-junction diode measurement with the amplified thermocouple voltage and reads out the 12-bit result onto the SO pin. A sequence of all zeros means the thermocouple reading is 0°C. A sequence of all ones means the thermocouple reading is +1023.75°C.

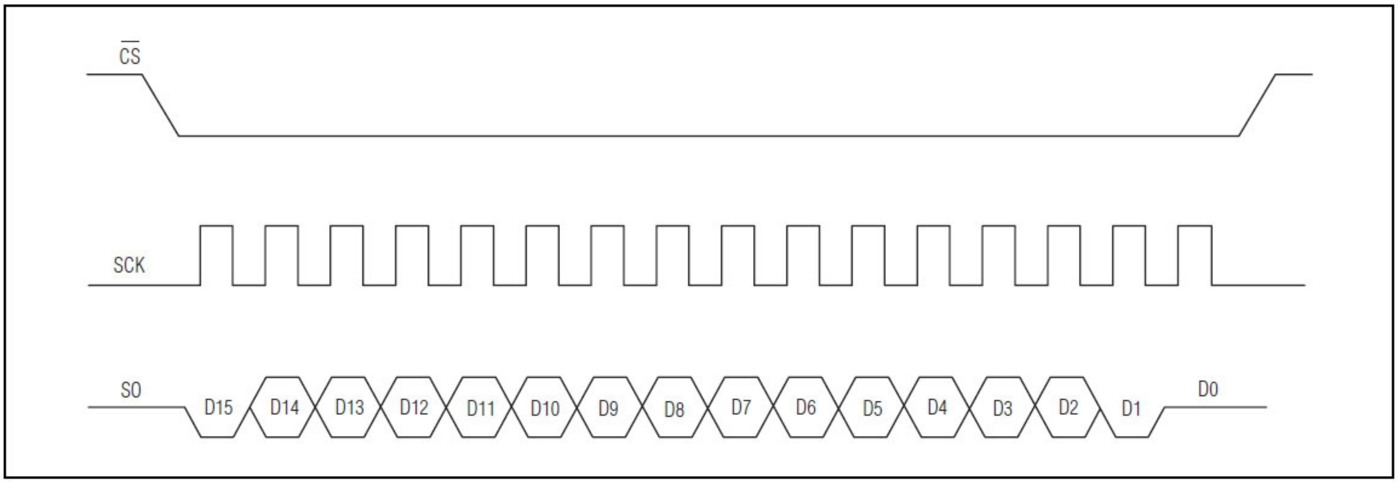
Serial Interface

The Typical Application Circuit shows the board interfaced with a microcontroller. In this example, the board processes the reading from the thermocouple and transmits the data through a serial interface.

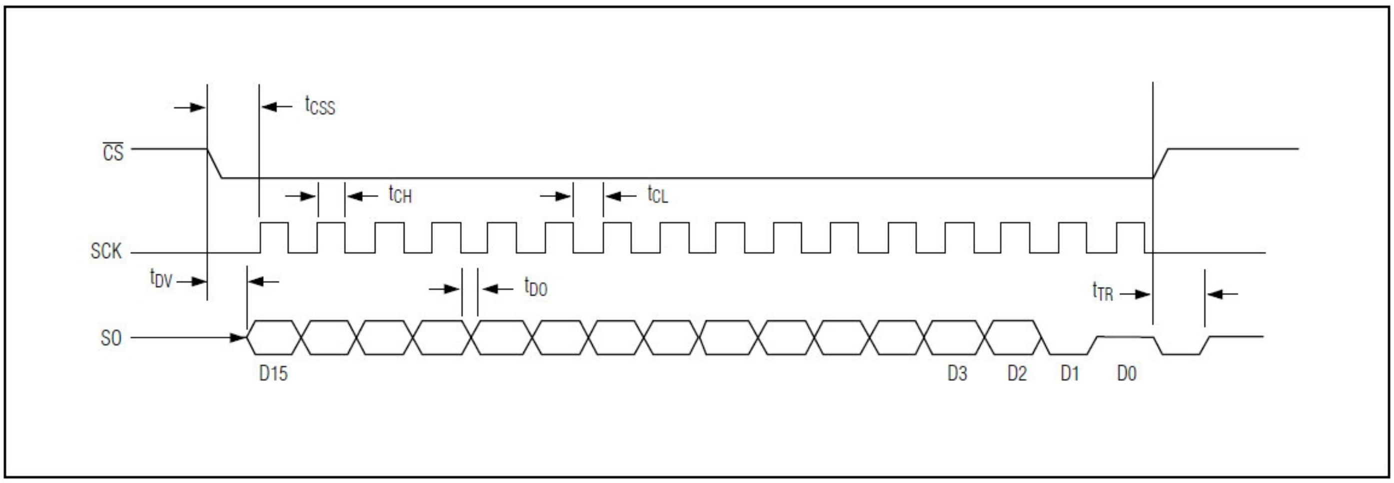


Force CS low and apply a clock signal at SCK to read the results at SO. Forcing CS low immediately stops any conversion process. Initiate a new conversion process by forcing CS high. Force CS low to output the first bit on the SO pin. A complete serial interface read requires 16 clock cycles. Read the 16 output bits on the falling edge of the clock. The first bit, D15, is a dummy sign bit and is always zero. Bits D14–D3 contain the converted temperature in the order of MSB to LSB. Bit D2 is normally low and goes high when the thermocouple input is open. D1 is low to provide a device ID for the board and bit D0 is three-state.

Serial interface protocol



Serial interface timing



SO output

BIT	DUMMY SIGN BIT	12-BIT TEMPERATURE READING												THERMOCOUPLE INPUT	DEVICE ID	STATE
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	MSB											LSB		0	Three-state

Open Thermocouple

Bit D2 is normally low and goes high if the thermocouple input is open.

Sample code for implementing in C language of any microcontroller

```
sbit CS = P2^0;
sbit SO = P2^1;
sbit SCK = P2^2;

//global error flag to tell you if a thermocouple is connected or not
unsigned char tc_error;

void init_sensor()
{
	CS = 1; // disable chip select
	SO = 0;
	SCK = 0;
}

float read_sensor()
{
	int i;
	unsigned int AdcResult, k; // 16 bit
	CS=0; // Active chip select
	SCK = 1; //Cycle the clock for dummy bit 15
	SCK = 0;
	//--- read ADC result 12 bit --------
	AdcResult=0;

	for(i=11;i>=0;i--) {
		SCK=1;
		k = 0;
		if(SO==1)
		k = 1 << i;
		AdcResult|=k;
		SCK=0; // falling clock
	}
	/* Read the TC Input inp to check for TC Errors */
	SCK = 1;
	if(SO==1)
		tc_error = 1;
	else
		tc_error = 0;
	SCK = 0;
	CS=1;
	//adjusts data to floating point format, and accounts for the decimal point
	return(float)(AdcResult/4.0);
}

void main()
{
	init_sensor();
	while(1)
	{
		if(tc_error)
			printf("Thermocouple Open");
		else
			printf("%01.2f%cC",read_sensor(),0xB0); // output eg. 35.6°C
		putchar(13); //newline character
		delayms(1000); // sample every second
	}
}
```